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Factors Which Influence the Yield and Consistency of Ice Cream

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Dairy Section

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30 A

SUMMARY

1. Cream decreases in viscosity by pasteurization; it increases in viscosity by aging as the fat content of the cream increases.

2. The yield of ice cream is less with fresh raw cream than with cream which has been aged for 24 to 48 hours. An increase of 6.6% in yield was obtained by aging the cream for 24 hours.

3. When pasteurized cream is used, the yield is also increased by aging the cream. By aging the cream for 24 hours the yield was increased 4.72%, with a further increase of 3.58% when aged for 48 hours.

4. When using homogenized cream a gain of 3.99% in overrun was obtained by aging the cream for 24 hours, while an additional gain of 2.09% was obtained by aging the cream for 48 hours.

5. The aged cream in all experiments produced an ice cream of a more perfect texture than was produced from the fresh cream.

6. Fillers do not increase or decrease the yield of resulting ice cream.

7. Results from experiments reported indicate that a temperature of about 6° F. for the circulating brine would be the most desirable when using a 20% raw cream. For pasteurized cream a temperature of from 8 to 10° F. gave the best results, while for emulsified cream about 10° F. and for homogenized cream 14° F. proved the most satisfactory.

8. The amount of mix in freezer influences the yield obtained. Most satisfactory results were obtained from a horizontal freezer when it was about half full of mix.

9. The daily overrun obtained should be figured by volume, however, it is of value in checking up our work to frequently determine the weight per gallon of ice cream.

10. The holding of ice cream does not influence the distribution of fat in the ice cream.

11. If ice costs $3.00 per ton and salt $7.00 per ton, then the cost of salt and ice used for freezing in the foregoing experiments amounted to $0.0058 per gallon of ice cream frozen to 27° F., and to $0.0075 when frozen to 26° F. For packing a 5 gallon container of ice cream the cost was $0.0144 per gallon.

FACTORS WHICH INFLUENCE THE YIELD AND CONSISTENCY OF ICE CREAM

BY M. MORTENSEN

The pasteurization, aging and homogenization of the cream used, the temperature of the circulating brine and the amount of the mix in the freezer all have an influence upon the yield and texture of ice cream. In some instances that influence is marked and has much to do with successful results in ice cream manufacture.

Just what influence these various factors exert was determined in a series of tests made by the author at the Iowa Agricultural Experiment station. The results of these tests are presented in this bulletin for the information of ice cream manufacturers. The bulletin also presents a comparison of the results obtained in figuring the daily ice cream yield by weight and by volume as well as the influence of holding ice cream on uniformity in fat content. There is also a discussion of some of the cost items in ice cream manufacture, such as salt and ice.

INFLUENCE OF PASTEURIZATION AND AGING OF CREAM ON ITS VISCOSITY

Both the pasteuriation and the aging of cream influence its viscosity and this viscosity in turn is largely responsible for the body and yield of ice cream. A series of tests were made to determine the specific viscosity of raw cream and of the same cream immediately after pasteurization and after it had been aged for periods of 24 hours, 48 hours and 72 hours after pasteurization. These tests were made on cream of fat contents varying from 12 to 35%. The acidity of the cream varied from 15 to 19%.

A Scott viscosimeter was used for the determination of viscosity. The cream to be tested was tempered to 60° F. and then 200 c.c. transferred to the viscosimeter. When the cream was at the proper temperature in the viscosimeter (60° F.), a 50 c.c. glass cylinder was filled with cream from the instrument so that exactly 50 c.c. was obtained. The time required for the flow of this amount of cream at 60° F. was determined by a stop watch; that time is known as "time viscosity," or the number of seconds required for a flow of 50 c.c. of any liquid at a given temperature. The time viscosity of a liquid in seconds divided by the number of seconds required for a flow of 50 c.c. of distilled water at 60° F. gives the "specific viscosity" of the liquid.

RESULTS OBTAINED

Table I gives the specific viscosity of raw cream, of the same cream immediately after pasteurization and after it had been

held at a temperature from 32 to 40° F. for periods of 24, 48 and 72 hours. Changes in viscosity due to pasteurization and aging are greater in rich than in thin cream, due mainly to the higher viscosity and to greater susceptibility to viscosity changes of the former. It is also, to some extent, due to the decrease in the smaller experimental error in proportion to the increase in length of time required to draw the 50 c.c. of cream.

It is difficult to prepare a satisfactory specific viscosity table for cream as there are so many factors that are not absolutely under the control of the experimenter, i. e., the percent of air in-

TABLE I—INFLUENCE OF THE PASTEURIZATION AND AGING OF CREAM ON ITS VISCOSITY.

No.	Per Cent Fat in Cream	Specific Viscosity of Cream				
		Raw Cream	Pasteurized Cream			
		Immediately Before Past.	Immediately After Past. & Cooling	24 hrs. After Past. & Cooling	48 hrs. After Past. & Cooling	72 hrs. After Past. & Cooling
1	12	1.13	1.13	1.13	1.11	1.11
2		1.11	1.11	1.11		1.11
3		1.13	1.11	1.11		
4		1.13	1.13	1.13	1.13	1.13
5	14	1.13	1.13	1.13	1.13	1.13
6		1.11	1.11	1.11		
7		1.13	1.11	1.11		
8		1.13	1.13	1.13	1.13	1.15
9		1.13	1.13	1.15		
10		1.15	1.13	1.13		
11	16	1.15	1.15	1.13	1.13	1.15
12		1.13	1.11	1.11		1.16
13		1.13	1.13	1.15	1.16	1.16
14	18	1.16	1.15	1.15	1.15	1.16
15		1.15	1.13	1.15		1.16
16		1.16	1.13	1.16		
17		1.16	1.15	1.16	1.18	1.18
18		1.16	1.15	1.16		
19		1.18	1.16	1.20		
20	20	1.18	1.16	1.18	1.18	1.20
21		1.18	1.16	1.18		1.20
22		1.20	1.18	1.18		
23		1.20	1.18	1.18	1.20	1.22
24		1.20	1.18	1.20		
25		1.22	1.16	1.22		
26	22	1.22	1.18	1.22	1.22	1.20
27		1.22	1.16	1.22		1.24
28		1.22	1.18	1.22		
29		1.22	1.20	1.22	1.24	1.25
30		1.22	1.18	1.25		
31		1.26	1.22	1.25		
32	24	1.24	1.22	1.25	1.25	1.22
33		1.29	1.20	1.25		1.25
34		1.27	1.20	1.24		
35		1.27	1.24	1.21	1.27	1.27
36		1.27	1.24	1.27		
37		1.27	1.24	1.27		
38	30	1.36	1.31	1.38	1.36	1.35
39		1.38	1.31	1.38		1.42
40		1.40	1.33	1.40		
41		1.38	1.31	1.38	1.42	1.42
42		1.38	1.35	1.46		1.49
43		1.42	1.36	1.46		
44	35	1.55	1.44	1.60	1.58	1.56
45		1.56	1.40	1.64		1.69
46		1.58	1.51	1.69		
47		1.60	1.47	1.60		

corporated in the cream during handling, the acidity of the cream, the kind of fermentation in the cream, etc. It is therefore impossible to produce a viscosity table with figures that are absolutely consistent, and table I is intended to show only in a general way the influence of pasteurization and aging of cream on its viscosity. As a general rule, the viscosity of the cream decreases with pasteurization and increases as the fat content of the cream increases with aging.

INFLUENCE OF AGING THE CREAM ON THE BODY AND TEXTURE IN ICE CREAM

Six experiments each were conducted with raw, pasteurized and homogenized cream. The cream that was frozen while fresh was cooled to 32-40° F. before mixing, while the aged cream was held at that temperature for 24 to 48 hours before mixing and freezing. Except for these changes, all conditions surrounding the freezing and handling of cream of different ages were identical.

RAW CREAM

For these experiments a 2½ gallon horizontal Miller-Tyson freezer was used. The mix was made as follows:

42 lbs. 20% cream
8 lbs. sugar
4 oz. vanilla

No filler was used. The ice cream was drawn at a temperature of 28° F. The thermometer used for these and following experiments was made especially for this work. It registered from 0 to 50° F. and was graduated so that one-tenth of a degree could be observed without difficulty. In each case the ice cream was measured in the same container, which was of standard size, and any partly filled container was measured as accurately as possible with a finely graduated ruler. The freezer was emptied of all ice cream and carefully cleaned between each experiment.

In all experiments, according to table II, the yield obtained was less with fresh cream than with cream which had been aged for 24 to 48 hours. The yield obtained from 24 hour and 48 hour old cream was the same in all cases except twice, when a slightly higher yield was obtained with the 24 hour old cream. Even here the differences were so slight that they may easily have been due to some experimental error. These few experiments indicate that the holding of raw cream for either 24 hours or 48 hours before freezing at a temperature from 32° F. to 40° F. will produce practically the same results, but that an increase in yield of 6.6% was obtained when aging the cream for 24 hours when comparing it to the yield obtained by freezing fresh cream.

The texture of all the ice cream produced was good, but that made from the fresh cream was slightly inferior to that made

TABLE II—INFLUENCE OF AGING RAW CREAM ON YIELD OBTAINED.

No.	Age of Cream	Richness of cream Pct.	Lbs. mix used for freezing	Gallons of Ice Cream Obtained		
				From Fresh Cream	From 24 hr. old Cream	From 48 hr. old Cream
1a*	Fresh	20	21	3.937		
1b	24 hr.	20	21		4.250	
1c	48 hr.	20	21			4.125
2a	Fresh	20	21	4.000		
2b	24 hr.	20	21		4.250	
2c	48 hr.	20	21			4.250
3a	Fresh	20	21	3.875		
3b	24 hr.	20	21		4.125	
3c	48 hr.	20	21			4.125
4a	Fresh	20	21	4.000		
4b	48 hr.	20	21		4.250	
4c	48 hr.	20	21			4.125
5a	Fresh	20	21	3.875		
5b	24 hr.	20	21		4.125	
5c	48 hr.	20	21			4.125
6a	Fresh	20	21	4.000		
6b	24 hr.	20	21		4.250	
6c	48 hr.	20	21			4.250
	Average			3.948	4.208	4.167

*The letter a combined with a number indicates that fresh cream was used for the experiment; b indicates that the cream had been held for 24 hours, and c that cream had been held for 48 hours.

from aged cream. There was no noticeable difference in texture between ice cream made from cream aged for 24 hours and 48 hours.

PASTEURIZED CREAM

The cream used for this experiment was pasteurized at a temperature of 145° F. for 25 minutes, and then cooled immediately to 40° F.; the aged cream was held at a temperature ranging from 40° F. to 32° F. The mix was prepared in accordance with the following formula:

44 lbs. 18% cream
8 lbs. sugar
4 oz. vanilla
4 oz. Boerner-Fry Co. ice cream powder

The specific gravity of this mix was 1.0618. A disc continuous freezer, size A, was used as a batch machine. The temperature of circulating brine was kept at 10° F. The ice cream was drawn at a temperature of 27° F., which gave the most satisfactory body with the pasteurized cream.

The yield from these and the following experiments was calculated from the weight of the first two gallons of ice cream drawn from the freezer and from the weight of the same container filled with mix. The overrun obtained was figured as follows:

$$\text{Percent overun} = \frac{\text{Wt. of mix—wt. of same vol. ice cream} \times 100}{\text{Weight of same vol. ice cream}}$$

Example. Suppose as in experiment 1a with fresh cream the weight of two gallons of ice cream is 10.125 pounds and the

weight of the same volume of mix 17.531 pounds. The per cent overrun is then qual to $\frac{17.531—10.125 \times 100}{10.125} = 73.16$ percent

The scales used were sensitive to within less than half an ounce. The ice cream container was supposed to hold exactly two gallons of ice cream but was nearly three per cent too large. The container was filled with ice cream from the freezer to above the edge and a sharp metal edged ruler was then drawn over the top so that the container would be exactly full. The freezer was emptied and thoroly cleaned before each experiment. The weighing of ice cream is more accurate than measuring for making comparative tests but less satisfactory for determining the overrun obtained in a commercial plant as will be explained later.

Table III indicates that in all experiments a higher yield was obtained from cream 24 hours old than from fresh cream, the gain being 4.72 per cent. In all experiments except c4 a higher yield was obtained from cream 48 hours than from cream 24 hours old. For some unknown reason lot c4 was slightly churned thus accounting for the reduction in yield. Comparing the yield of 24 hour and 48 hour old cream and leaving out of consideration b4 and c4 the data shows a gain in yield of 3.58 per cent in favor of the 48 hour old cream.

The body of the ice cream made from fresh cream was weak and coarse, that from the 24 hour old cream was fairly satisfactory while that from the 48 hour old cream was a trifle light.

TABLE III—INFLUENCE OF AGING PASTEURIZED CREAM ON YIELD OBTAINED.

No.	Age of Cream	Richness of Cream	Lbs. Mix	Weight in pounds of 2 gallons of Ice Cream			Overrun Figured in Per Cent
				From Fresh Cream	From 24 Hr. Old Cream	From 48 Hr. Old Cream	
1a	Fresh	18	28¼	18.124			73.16
1b	24 hrs.	18	28¼		9.594		82.73
1c	48 hrs.	18	28¼			9.344	87.62
2a	Fresh	18	28¼	10.219			71.55
2b	24 hrs.	18	28¼		10.000		75.31
2c	48 hrs.	18	28¼			9.500	84.54
3a	Fresh	18	28¼	10.250			71.03
3b	48 hrs.	18	28¼		9.437		85.77
3c	48 hrs.	18	28¼			9.250	89.52
4a	Fresh	18	28¼	9.812			73.67
4b	24 hrs.	18	28¼		9.437		85.77
4c	48 hrs.	18	28¼			9.750	79.81
5a	Fresh	18	28¼	10.250			71.03
5b	24 hrs.	18	28¼		9.750		79.81
5c	48 hrs.	18	28¼			9.500	84.54
6a	Fresh	18	28¼	10.375			68.97
6b	24 hrs.	18	28¼		10.000		74.23
6c	48 hrs.	18	28¼			9.562	83.34
	Average			10.172	9.703	9.484	

HOMOGENIZED CREAM

The cream used for these experiments was pasteurized to 145° F. for 24 minutes. It was then passed through a homogenizer at the pasteurizing temperature at a pressure of 150 kilograms per square centimeter. Immediately after homogenization it was cooled to 40°F. and divided into three lots and held under the same conditions as the cream used for the experiments with pasteurized cream. The methods of procedure, the temperature of brine and the temperature of ice cream when drawn were also the same.

Table IV indicates that in every instance a higher yield was obtained with 24 hour old than with fresh cream, the gain being 3.99 per cent and that a higher yield was obtained from 48 hour old than from 24 hour old cream, the gain being 2.09 per cent.

The body of the ice creams made with fresh cream and with aged cream was very good and much superior to that made with raw cream or with cream which had been merely pasteurized.

TABLE IV—INFLUENCE OF AGING HOMOGENIZED CREAM ON YIELD OBTAINED.

No.	Age of Cream	Richness of cream Pct.	Lbs. Mix	Weight in pounds of 2 gallons of ice cream.			Overrun Figured in Pct.
				Fresh Cream	From 24 hr. old cream	From 48 hr. old cream	
1a	Fresh	18	28¼	10.469			67.45
1b	24 hrs.	18	28¼		10.125		73.16
1c	48 hrs.	18	28¼			9.937	76.42
2a	Fresh	18	28¼	9.937			76.42
2b	24 hrs.	18	28¼		9.500		84.54
2c	48 hrs.	18	28¼			9.375	87.00
3a	Fresh	18	28¼	10.500			66.96
3b	24 hrs.	18	28¼		10.187		72.09
3c	48 hrs.	18	28¼			10.031	74.77
4a	Fresh	18	28¼	10.000			75.31
4b	48 hrs.	18	28¼		9.375		87.00
4c	48 hrs.	18	28¼			9.187	90.82
5a	Fresh	18	28¼	10.625			65.00
5b	24 hrs.	18	28¼		10.437		67.97
5c	48 hrs.	18	28¼			10.312	70.01
6a	Fresh	18	28¼	10.375			68.97
6b	24 hrs.	18	28¼		9.906		76.97
6c	48 hrs.	18	28¼			9.469	85.14
Average				10.318	9.922	9.718	

THE INFLUENCE OF FILLERS ON THE YIELD OF ICE CREAM.

The use of fillers (often known as binders or stabilizers) for the ice cream mix when making commercial ice cream has been found advantageous in producing a more permanent and smoother body. In order to test the influence of such fillers on the yield of ice cream various substances were used including gelatin, milk powder, starch, and two commercial powders, one manu-

factured by Boerner Fry & Co. of Iowa City, Iowa, the other known as Velv Olene.

The milk powder and commercial fillers were mixed with sugar before being added to the cream in order to divide up the powder between the sugar particles. By this process the powder was more thoroly distributed thruout the cream and the formation of lumps prevented.

A sheet gelatin of the highest quality obtainable was dissolved in water by mixing in the proportion of 4 oz. of gelatin to 1 pint of water and heating to 140°F. until the gelatin was thoroly dissolved. The gelatin solution was added without cooling and the mix was stirred briskly during the addition and long enough afterwards to make certain that the gelatin solution had been thoroly distributed. Raw starch is without value as a filler. It is found in the form of minute granules, the outer part of which consists of a covering known as starch cellulose; this cellulose is not soluble in water but it ruptures when the granules are boiled in water and the inner part known as starch granulose, is dissolved in the water and forms a paste.

The starch paste used in this experiment was prepared as follows; 8 ounces of starch were thoroly mixed with two quarts of milk and heated under constant stirring, more milk being added gradually as the paste increased in thickness. Enough milk was added to make three gallons of paste, after it had been held at the boiling point for 30 minutes.

The ice cream was frozen in a disc continuous freezer, size A, operated as a batch machine. The freezer was thoroly cleaned after the completion of each experiment. The amount of ice cream obtained was measured with a finely graduated measuring rod.

Tables V, VI and VII indicate that the filler did not increase or decrease the yield of ice cream.

According to table V Velv Olene produced a yield slightly lower than that of the other commercial fillers, and the reason for this should be explained in justice to the manufacturer. Velv Olene produced the highest viscosity in the mix and a mix of high viscosity should be frozen with brine of a slightly higher temperature if the proper yield is to be obtained. It seems probable that one filler will produce as satisfactory a yield as another but the conditions for obtaining the most satisfactory yield may have to be changed somewhat in accordance with the differences in the character of the fillers.

From tests reported in table VI it may be concluded that the amount of filler used, if held within practical limits, will not influence the yield of the resulting product.

TABLE V—INFLUENCE OF GELATIN AND COMMERCIAL FILLERS ON YIELD OF ICE CREAM.

No.	Temp. of Pasteurization of Cream	Age of Cream in Hours	Temp. of Cream in degrees F.	Temp. of mix in degrees F.	Acidity of cream in per cent	% fat in cream	Viscosity of cream	Viscosity of mix	Kind of filler and amount in oz.	Lbs. mix used	Temp. of brine in degree F.	Temp. of ice cream when drawn	Am't of Ice Cream in gallon obtanied with			
													8 oz. Gelatin	4 oz. Boerner Fry	6 oz. Velv Olene	No filler
1 a	140°	28	32	40	.17	19.5		1.43	Gel. 8	100	10	27	18 3-4	19 11-32		
1b		28	32	35	.17	19.5		1.41	B. F. 4	100	10	27			18 3-4	
1c		28	32	36	.17	19.5		1.96	V. O. 6	100	10	27				20 1-2
1d		28	32	36	.17	19.5		1.34	None	100	10	27				
2a	180°	32	40	36	.13	18	1.18	1.36	Gel. 8	100	10	28	19 3-4	21 7-8		
2b		32	40	36	.13	18	1.18	1.36	B. F. 4	100	10	28			21 1-8	
2c		32	40	36	.13	18	1.18	1.81	V. O. 6	100	10	28				20 1-2
2d		32	40	36	.13	18	1.18	1.81	None	100	10	28				
3a	180°	28	37	42	.15	20	1.18	1.45	Gel. 8	100	10	28	19 1-2	21 1-16		
3b		28	37	40	.15	20	1.18	1.45	B. F. 4	100	10	28			21	
3c		28	37	41	.15	20	1.18	1.45	V. O. 6	100	10	28				21
3d		28	37	41	.15	20	1.18	1.25	None	100	10	28				
4a	180°	36	42	52	.15	20	1.18	1.48	Gel. 8	96	10	28	19 1-2	19 3-4		
4b		36	42	48	.15	20	1.18	1.48	B. F. 4	96	10	28			18 7-8	
4c		36	42	44	.15	20	1.18	2.12	V. O. 6	96	10	28				20 1-4
4d		36	42	47	.15	20	1.18	1.27	None	96	10	28				
5a	140°	36	42	50	.158	20	1.18	1.45	Gel. 8	100	9	28	19 5-8	20		
5b		36	42	46	.158	20	1.18	1.36	B. F. 4	100	9	28			19 3-4	
5c		36	42	47	.158	20	1.18	1.63	V. O. 6	100	9	28				20
5d		36	42	47	.158	20	1.18	1.27	None	100	9	28				
												Total	97 1-8	102 1-32	99 1-2	102 1-4

TABLE VI--INFLUENCE OF STARCH AND MILK POWDER AS FILLERS ON YIELD OF CREAM.

No.	Temp. of Pasteurization of Cream	Age of Cream in Hours	Temp. of Cream in degrees F.	Temp. of mix in degrees F.	Acidity of cream in per cent	% fat in cream	Viscosity of cream	Viscosity of mix	Kind of filler and amount in oz.		Lbs. mix used	Temp. of brine in degree F.	Temp. of ice cream when drawn	Am't Ice Cream in gallon obtained wtih		
														32 oz. Milk powder	8 oz. Starch	No filler used
1a	140°	30	40	44	.137	19.5	1.18	1.35	Milk Pdr.	32	100	9	28	20		
1b		30	40	45	.137	19.5	1.18	1.35	Starch	8	100	9	28		20	
1c		30	40	42	.137	19.5	1.18	1.22	No filler		100	9	28			20
2a	140°	24	39	35	.143	19	1.18	1.36	Milk Pdr.	32	100	9	28	19 5-8		
2b		24	39	37	.143	19	1.18	1.36	Starch	8	100	9	28		20	
2c		24	39	35	.143	19	1.18	1.31	No filler		100	9	28			19 3-4
3a	170°	30	33	35	.188	19	1.22	1.36	Milk Pdr.	32	100	9	28	20 5-8		
3b		30	33	37	.188	19	1.22	1.38	Starch	8	100	9	28		20 3-4	
3c		30	33	35	.188	19	1.22	1.27	No filler		100	9	28			20 7-8
4a	170°	24	34	35	.163	20			Milk Pdr.	32	100	9	28	20 1-4		
4b		24	34	35	.163	20			Starch	8	100	9	28		20 1-4	
4c		24	34	35	.163	20			No filler		100	9	28			20 1-2
													Total	80 1-2	80 7-8	81 1-8

TABLE VII—INFLUENCE OF AMOUNT OF FILLER ON YIELD OF ICE CREAM.

No.	Temp. of Pasteurization of Cream	Age of Cream in Hours	Temp. of Cream in degrees F.	Temp. of mix in degrees F.	Acidity of cream in per cent	% fat in cream	Viscosity of cream	Viscosity of mix	Kind of filler and amount in oz.		Lbs. mix used	Temp. of brine in degree F.	Temp. of ice cream when drawn	Amount of Ice Cream in gallon obtained with		
														8 oz. Gelatin	16 oz. Gelatin	16 oz. Starch
1a	170°	24	42	45	.147	20.5	1.22	1.31	Gelatin	8	100	10	28	19 1-2		
1b		24	42	46	.147	20.5	1.45	1.31	Gelatin	16	100	10	28		19 5-8	
1c		24	42	44	.147	20.5	1.22	1.31	Starch	16	100	10	28			19 3-4
2a	170°	30	33	44	.147	19.5	1.26	1.36	Gelatin	8	100	10	28	18 1-8		
2b		30	33	43	.147	19.5	1.26	1.54	Gelatin	16	100	10	28		18 1-4	
2c		30	33	38	.147	19.5	1.26	1.36	Starch	16	100	10	28			18 3-4
3a	170°	48	33		.153	19.	1.22	1.36	Gelatin	8	100	10	28	20 1-4		
3b		48	33		.153	19.	1.22	1.45	Gelatin	16	100	10	28		20 1-4	
3c		48	33		.153	19.	1.22	1.28	Starch	16	100	10	28			20 3-4
4a	170°	48	32		.142	20.		1.36	Gelatin	8	100	10	28	19 7-8		
4b		48	32		.142	20.		1.60	Gelatin	16	100	10	28		19 7-8	
4c		48	32		.142	20.			Starch	16	100	10	28			20 3-16
													Total	77 6-8	78	79 7-16

INFLUENCE OF TEMPERATURE OF CIRCULATING BRINE ON YIELD OF ICE CREAM.

The mix prepared for these experiments was the same as that made from pasteurized cream. The freezer used was a disc continuous freezer, size, A. The circulating brine was held at 8°F., 10°F., 12°F. and 14°F., the same mix being used for each of four temperatures mentioned. The first two gallons of ice cream drawn from each lot were weighed and the results recorded.

Table VIII indicates that in experiment No. 1 the 12°F. brine and the 14° brine produced the same result; in all other experiments there was a gradual decrease in weight as the temperature of circulating brine was increased.

Altho the temperatures of the brine employed in these experiments may be considered fairly representative of commercial conditions, it was deemed advisable to try the effect of lower temperatures. Four experiments were therefore conducted with circulating brine at 4°, 6° and 8° F. with the results shown in table IX. At these low temperatures there is a marked difference in weight of ice cream obtained.

At these low temperatures there is marked difference in weight of ice cream obtained.

Table X summarizes these results and shows the decrease in weight and the corresponding increase in yield as the temperature of the circulating brine increases. The per cent gain reported under 6° F. is the per cent gain in yield of ice cream

TABLE VIII—INFLUENCE OF TEMPERATURE OF CIRCULATING BRINE ON YIELD OF CREAM OBTAINED.

Ex. No.	Age of Cream in hrs	% Fat in Cream	Treatment of Cream	Temp. Mix in Deg. F.	Lbs. Mix for each Batch	Temp. Ice Cream Was drawn in Deg. F.	Weight in Lbs. of 2 Gal. Ice Cream when frozen with brine at the following temperatures: 8° F.	10° F.	12° F.	14° F.
1	96	20	R	42	25	27	9.84	9.62	9.31	9.31
2	96	20	R	42	25	27	9.91	9.69	9.31	9.12
3	72	19½	R	53	25	27	9.44	9.19	8.94	8.75
4	72	19½	R	53	25	27	9.44	9.25	8.94	8.81
5	48	20	P	43	25	27	10.16	9.91	9.78	9.19
6	48	20	P	43	25	27	10.19	10.03	9.78	9.06
7	24	20	P	46	25	27	10.00	9.91	9.72	9.31
8	24	20	P	46	25	27	10.03	9.87	9.69	9.25
9	120	20	E	46	25	27	10.41	10.09	9.81	9.44
10	120	20	E	46	25	27	10.41	10.16	9.94	9.44
11	48	19	E	48	25	27	10.00	9.72	9.44	9.19
12	48	19	E	48	25	27	10.00	9.75	9.31	9.22
13	24	20	H	50	25	26	10.87	10.62	10.53	10.50
14	24	20	H	50	25	26	11.09	10.75	10.69	10.41
15	48	19½	H	46	30	26	10.60	10.37	10.16	9.81
16	48	19½	H	46	30	26	10.44	10.19	10.09	9.78
						Average	10.18	9.94	9.71	9.41

R—Raw; P—Pasteurized; E—Emulsified; H—Homogenized.

TABLE IX—INFLUENCE OF TEMPERATURE OF BRINE ON YIELD OF ICE CREAM.

Weight in pounds of two gallons of ice cream

	Temp. of brine 4 deg. F.	Temp. of brine 6 deg. F.	Temp. of brine 8 deg. F.
Exp. 1	11.81	11.56	11.25
Exp. 2	11.75	11.59	11.31
Exp. 3	11.78	11.59	11.44
Exp. 4	11.78	11.62	11.44

TABLE X—SUMMARY OF RESULTS SHOWING INFLUENCE OF TEMPERATURE OF CIRCULATING BRINE ON YIELD OF ICE CREAM.

Treatment of Cream	Tem. at which Ice Cream was Drawn	Temperature of Brine											
		4° F.	6° F.		8° F.		10° F.		12° F.		14° F.		
		Wt. in lbs. per gal. Ice Cream	Wt. in lbs. per gal. Ice Cream	% gain	Wt. in lbs. per gal. Ice Cream	% gain	Wt. in lbs. per gal. Ice Cream	% gain	Wt. in lbs. per gal. Ice Cream	% gain	Wt. in lbs. per gal. Ice Cream	% gain
Raw	27° F				4.83		4.72	2.33	4.56	3.51	4.50	1.33
Past.	27° F				5.05		4.96	1.81	4.87	1.87	4.60	5.87
Emulsified	27° F				5.10		4.96	2.82	4.81	3.12	4.66	3.22
Homogenized	26° F	5.89	5.79	1.73	5.68	1.94	5.24	2.48	5.18	1.16	5.06	2.37
	26° F				5.37							

obtained when the circulating brine was 6° F. as against that obtained when the brine was 4° F. The gain shown under 8° F. is the per cent gain in yield when the temperature of the brine was increased from 6 to 8° F., etc. It will be noted that this increase in yield was quite constant for each two degrees increase in the temperature of the circulating brine within the range of from 4° F. to 14° F., which covers the temperatures employed in our ice cream factories.

The increase in yield obtained with an increased temperature of the brine is due to the increase in time required for freezing. During the entire freezing process air is beaten into the cream, therefore the longer the time required for freezing, up to a certain limit, the more air will be incorporated. This holds true if the cream is of good body. Cream frozen while fresh or cream that has been injured in pasteurization is likely to churn more or less during freezing. Ice cream from such cream will contain butter particles and when eaten will stick to the roof of the mouth. A comparatively small yield will be obtained because the mix becomes less viscous as the formation of butter particles increases, and, altho the butter particles do not prevent the incorporation of air, the reduction in the viscosity of the mix causes it to have less power for retaining the air which is being beaten into it.

The viscosity of cream is a big factor in determining the temperature of the circulating brine that gives the most satisfactory yield. It will be noted from table X that the raw, pasteurized, emulsified and homogenized creams all differed in the yield obtained under the same conditions. Raw cream of a satisfactory body produced the highest yield. The viscosity of the raw cream is somewhat higher than that of pasteurized cream, less than that of emulsified cream and considerably less than that of homogenized cream. The greater the viscosity, the greater becomes the resistance against the incorporation of air. With the more viscous mixes, the air cells incorporated are smaller and partly for that reason and partly on account of the higher viscosity the air cells are more completely retained. The raw cream seems to have a low enough viscosity to afford comparatively little resistance to the incorporation of air and at the same time to possess sufficient viscosity to retain the air reasonably well. However, with brine at 14° F. a comparatively slight gain was made over a brine at 12° F. This was probably due to the fact that the ice cream produced by the 12° F. brine contained nearly as much air as can be retained in cream of such richness and character.

The pasteurized cream produced a smaller yield than the raw cream and only a minor increase in yield for increases in temperature of the circulating brine up to 14° F., when a big in-

TABLE XI—TABLE SHOWING TIME REQUIRED FOR FREEZING.

Average time in minutes required for freezing 5 gallons of ice cream, with the disc continuous freezer, size A, with brine at 8, 10, 12 and 14° F. Homogenized cream was frozen to 26° F.; other kinds to 27° F.

Treatment of Cream	Brine at 8° F.	Brine at 10° F.	Brine at 12° F.	Brine at 14° F.
Raw	5.75	6.50	7.37	8.25
Pasteurized	5.56	6.25	7.00	9.37
Emulsified	6.00	6.69	7.50	8.50
Homogenized	8.75	10.50	12.00	15.31

crease was experienced. The pasteurized cream, having the lowest viscosity of any of the cream used, will exert the least resistance against the incorporation of air; therefore, the air cells become larger, but due to the lower viscosity of mix the air cells are not so largely retained. With brine at 14° F., however, the cream is held in the freezer for a longer period (see table X) while it is in a firmer condition, and it is immediately after this ice cream has been frozen to a somewhat firm consistency that it retains the air.

Emulsified and homogenized creams produced less yield in comparison to their viscosities. This indicates that the period of freezing should be prolonged and the higher temperatures should be used if the most satisfactory results are to be obtained. Homogenized cream will produce a high yield if sufficient time is allowed for the incorporation of air cells.

Most manufacturers consider ice cream weighing about five pounds per gallon most satisfactory in body and texture and our experience confirms this. Table X indicates that in order to produce a cream of that weight a temperature of about 6° F. for the circualting brine was the most desirable for raw cream of about 20% fat, mixed as in these experiments. For pasteurized cream a temperature of from 8 to 10° F. gave the best results, while for emulsified cream about 10° F. and for homogenized cream 14° F. proved the most satisfactory.

The time required for freezing under different conditions is shown in table XI.

INFLUENCE OF THE AMOUNT OF MIX IN THE FREEZER ON THE YIELD OBTAINED

The mix prepared for these experiments was the same as that used for previous experiments. The freezer was a disc continuous freezer, Size A. For each experiment double batches of 15 pounds, 20 pounds, 25 pounds and 30 pounds of mix were used, one batch being frozen to 27° F. and the other to 26° F. Twenty-five pounds would bring the mix up to the center of the discs and may be considered the proper amount to use in ordinary work. The circulating brine was held at 10°. The same mix

was used for the different runs made under each experiment number. The weights of the first two gallons of ice cream drawn from each batch are recorded in table XII.

In all experiments, except No. 7, when the ice cream was drawn from the freezer at 26° F., there was a decrease in the weight of the resulting ice cream which corresponded reasonably well to the increased amount of mix in freezer. When drawing the ice cream at 27° F. there was a similar decrease in weight when mixes of from 15, 20 and 25 pounds were used, but there was most often an increase when the mix made up from raw and pasteurized cream was increased to 30 pounds.

Table XIII is a summary of table XII. The per cent gain indicated represents the per cent gain in yield obtained by increasing the amount of mix from 15 to 20 pounds, from 20 to 25 pounds and from 25 to 30 pounds. It is interesting to note that when freezing raw, pasteurized and emulsified cream to 27° F. the greatest gain in yield was obtained when the mix was increased from 15 to 20 pounds, there was less gain when the mix was increased from 20 to 25 pounds and a loss when the mix was increased from 20 to 25 pounds and a loss when the mix was increased from 25 to 30 pounds with raw and pasteurized cream

TABLE XII—INFLUENCE OF THE AMOUNT OF MIX USED ON THE YIELD OF ICE CREAM.

No.	Kind of cream used	Age of cream	Temp. of mix	Temp. of ice cream when drawn	Weights in pounds of 2 gallons of ice cream when following amounts of mix were used			
					15 lbs.	20 lbs.	25 lbs.	30 lbs.
1	Raw	48 hrs	35 F.	26 F.	10.25	10.06	9.81	9.63
	"	48 hrs	35 F.	27 F.	10.38	9.63	9.19	9.19
2	"	96 hrs	35 F.	26 F.	11.31	10.66	9.69	9.56
	"	96 hrs	35 F.	27 F.	10.03	9.25	9.00	9.12
3	"	48 hrs	55 F.	26 F.	11.44	11.12	11.00	10.25
	"	48 hrs	55 F.	27 F.	10.12	9.44	9.12	9.25
4	Past.	48 hrs	41 F.	26 F.	10.38	10.63	10.25	9.63
	"	48 hrs	41 F.	27 F.	10.12	9.75	9.56	9.50
5	"	24 hrs	45 F.	26 F.	11.06	10.69	10.41	10.12
	"	24 hrs	45 F.	27 F.	10.44	9.88	9.66	9.75
6	"	48 hrs	43 F.	26 F.	10.88	10.69	10.44	10.00
	"	48 hrs	43 F.	27 F.	10.31	9.81	9.69	9.88
7	Emulsified	48 hrs	41 F.	26 F.	13.00	13.12	12.69	12.12
	"	48 hrs	41 F.	27 F.	12.38	11.97	11.59	11.44
8	"	48 hrs	50 F.	26 F.	11.38	10.75	10.38	10.31
	"	48 hrs	50 F.	27 F.	11.25	10.35	10.12	10.38
9	"	72 hrs	37 F.	26 F.	11.19	10.69	10.19	9.88
	"	72 hrs	37 F.	27 F.	10.94	10.56	10.25	10.19
10	"	48 hrs	41 F.	26 F.	10.50	10.25	10.00	9.81
	"	48 hrs	41 F.	27 F.	10.75	10.31	10.12	10.00
1	Homogen-ized	36 hrs	43 F.	26 F	12.38	12.22	11.84	11.56
	"	36 hrs	43 F.	27 F.	12.63	12.12	11.69	11.19
12	"	36 hrs	39 F.	26 F.	12.22	11.47	11.25	10.75
	"	36 hrs	39 F.	27 F.	12.22	11.47	10.66	10.12
13	"	48 hrs	46 F.	26 F.	11.73	10.84	10.25	9.91
	"	48 hrs	46 F.	27 F.	11.06	10.69	10.38	9.94
14	"	48 hrs	41 F.	26 F.	12.53	12.12	12.00	11.41
	"	48 hrs	41 F.	27 F.	12.12	11.94	11.41	11.38

TABLE XIII—INFLUENCE OF THE AMOUNT OF MIX AND THE TEMPERATURE OF ICE CREAM WHEN DRAWN ON THE YIELD OF ICE CREAM.

Kind of cream used	Temp. drawing	Amount of Mix							
		15 lbs.		20 lbs		25 lbs.		30 lbs.	
		Wt. 1 gal. ice cream	Per Cent Gain	Wt. 1 gal. ice cream	Per Cent Gain	Wt. 1 gal. ice cream	Per Cent Gain	Wt. 1 gal. ice cream	Per Cent Gain
Raw	27° F.	5.09		5.31	7.84	4.55	3.74	4.59	-0.87
Raw	26° F.	5.50		5.31	5.58	5.08	4.53	4.91	3.46
Past.	27° F.	5.14		4.91	4.68	4.82	1.87	4.85	-0.62
Past.	26° F.	5.39		5.33	1.13	5.18	2.90	4.96	4.44
Emulsified	27° F.	5.66		5.39	5.01	5.27	2.28	5.25	0.38
Emulsified	26° F.	5.76		5.60	2.86	5.41	3.51	5.26	2.85
Homogenized	27° F.	6.00		5.78	3.81	5.52	4.71	5.33	3.56
Homogenized	26° F.	6.11		5.82	4.98	5.67	2.64	5.45	4.04

and a very small gain with emulsified cream. The homogenized cream gave very different results. With it the gain was nearly in proportion to the increase in the amount of mix.

Two principal agents are responsible for the incorporation of air; one is the paddles or the discs which carry the air and force it into the mix, and the other is the mix itself. This mix is carried by the paddles or discs and encloses a certain amount of air and force it into the mix when it falls back. Fifteen pounds of mix in a freezer of a normal capacity of 25 pounds will reach only a short distance up on the discs. There is therefore only a small disc surface to carry the air into the cream and on account of the comparatively low viscosity of the mix only a small amount of mix is carried along with the discs. The active disc surface is greatly increased with the increase of the amount of mix to 20 pounds. An increase of another 5 pounds brings the mix up to the center of the coil and increases the active disc surface to a less extent, altho we are now making use of as much active disc surface as is available and if the freezer is filled above that point, the amount of disc surface above the mix surface, which carries air and mix, is decreased in size and as a result the yield is decreased. The different results obtained with the homogenized cream when frozen to the same temperature are due to the greater viscosity of the mix, more of the mix being carried with the discs, the surface of the mix being thereby lowered sufficiently to give a larger active disc surface with a slightly greater amount of mix than when cream of lower viscosity is being frozen.

The results obtained when the ice cream was drawn at 26° F. differ somewhat from the results obtained when ice cream was drawn at 27° F. This is particularly noticeable in 30 pound batches from raw, pasteurized and emulsified cream.

Table XIII also gives the per cent loss in weight and consequent gain in yield when ice cream was frozen to 27° F. as compared to 26° F. Ice cream made from raw, pasteurized or emulsified cream is of the most desirable consistency at about 27° F. Homogenized cream, however, produces an ice cream which is rather soft at that temperature and with it 26° F. has proved to be a more satisfactory temperature for drawing. After the ice cream has reached a certain degree of firmness some of the air cells will be worked out by continued agitation. It will be observed from table XIV that for raw, pasteurized and emulsified cream the greatest loss in yield when ice cream is frozen from

TABLE XIV—YIELD IN ICE CREAM WHEN DRAWN AT 27° AND 26° F.

Percent loss in yield when ice cream was frozen from 27° F. to 26° F. with following amounts of mix for each batch.

	15 lbs.	20 lbs.	25 lbs.	30 lbs.
Raw	8.05%	12.50%	11.65%	6.97%
Pasteurized	4.86%	8.55%	7.47%	2.27%
Emulsified	1.77%	3.90%	2.66%	0.19%
Homogenized	1.83%	0.70%	2.72%	2.25%

27° to 26° F. is experienced with the 20 and 25 pound batches for the reason that these batches are of such a size as will insure the most agitation. The reason for the difference in the case of the homogenized cream has already been explained.

The greatest loss is obtained from ice cream manufactured from raw cream, then follows that made from pasteurized, emulsified and homogenized creams, respectively. This difference is due to the size of the incorporated air cells. The raw and pasteurized creams are lower in viscosity and therefore the resistance toward the incorporation of air is less and large air cells will be formed; however, the pasteuried cream is somewhat lower in viscosity than the raw cream so the ice cream made from it lacks the power to retain the larger air cells and the smaller air cells, which are the only ones retained, are not so readily expelled by overfreezing or overworking. This is particularly evident in the case of the ice cream made from emulsified and homogenized cream.

It is reasonable to suppose that in repacking or retailing ice cream the rate of loss in volume will differ much in the different kinds of cream used. The greatest loss will be in ice cream made from raw cream and the lowest loss in ice cream made from emulsified or homogenized cream. This explains the fact so well known to the dealers that the emulsified and homogenized creams deliver more portions of a given size per gallon of ice cream than do raw and pasteuried creams.

Conclusions.

In considering the body of ice cream the following factors should be taken into account: (1) the air cells; (2) the fillers added to the mix; (3) the milk solids of the cream. Each of these factors influences directly or indirectly the texture, the firmness and the keeping quality of the ice cream.

Of these three factors the air cells play the most direct part. The body of ice cream is made up of air cells with small portions of frozen mix between. It is important, therefore, that the portions of mix become as finely divided as possible because the smaller they are the smaller will be the ice crystals formed. If the air has been incorporated into the ice cream in the form of numerous small cells the texture will be smooth and the body firm. A small air cell is stronger than a larger one because the air pressure within increases as the size of the air cells decrease. If the air cells are too large, the cell walls will lack strength and the surrounding pressure will cause them to collapse, the enclosed air will escape and the cell wall will form a comparatively large particle of ice, which will melt slowly on the palate and produce the sensation of coarseness. If the ice cream at that time has not been hardened sufficiently and is in a semi-frozen condition, the broken cell wall is in a partly liquid condition and will readily unite with other surplus liquid forming pockets, which will freeze into coarse crystals when the ice cream is properly repacked. The increase in coarseness of ice cream is accompanied by a decrease in volume. This decrease is naturally most pronounced if the ice cream is kept in a somewhat soft condition as the air will thus meet with less resistance on its upward passage.

Homogenization of cream plays an important part in controlling the size of air cells. (Figs. 1 and 2.) On account of the increased viscosity of homogenized cream the air is beaten into the mix with greater difficulty and the air cells are smaller. Any factor which tends to increase the viscosity of the mix will also tend to reduce the size of the air cells if the viscosity is increased without decreasing the specific gravity of the mix; if the viscosity increase is due to a higher fat content as in the case of whipping cream or other rich cream, the specific gravity of the mix is comparatively low and there is less resistance toward the incorporation of air and accordingly the incorporated air cells are larger. The increased viscosity of homogenized cream is due largely to the breaking up of fat globules, since the total surface of numerous small fat globules is greater than the surface of the original larger globules the former will take up more serum as fixed serum. Thus homogenization answers a second

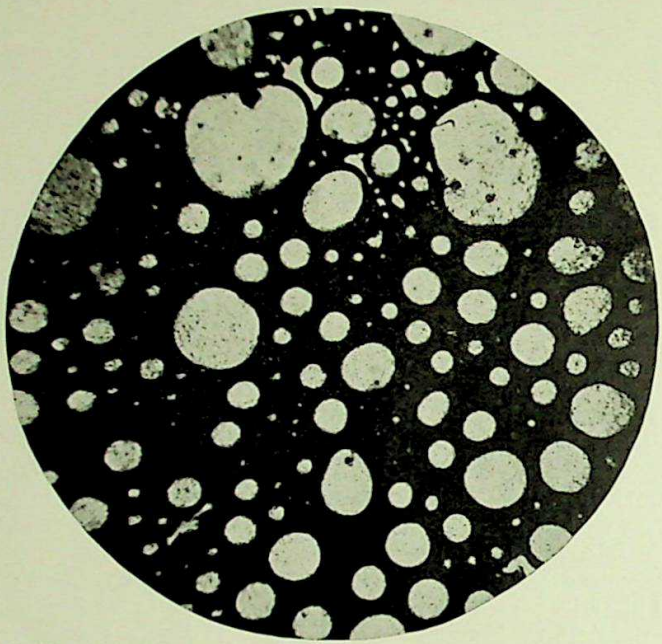

Fig. 1. This microphotograph shows the air cells in ice cream made from pasteurized cream which has not been homogenized. Note that the cells are larger than in fig. 2

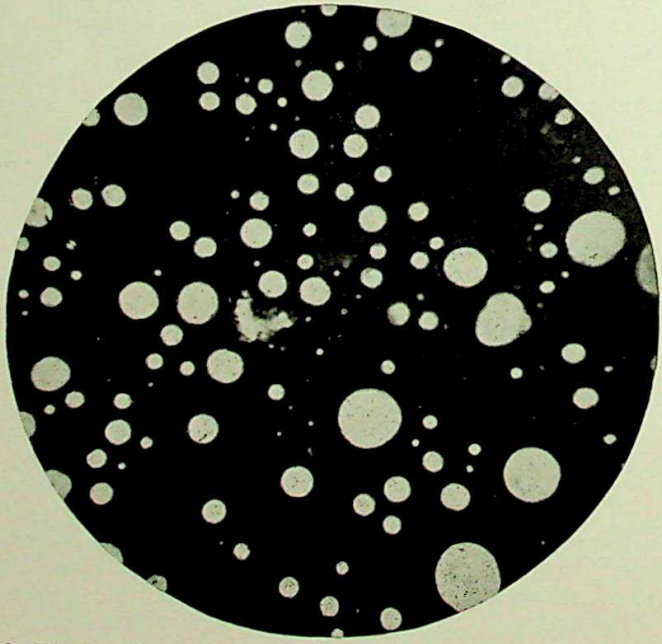

Fig. 2. This microphotograph shows the air cells in ice cream made from pasteurized and homogenized cream. The air cells are smaller than in fig, 1

purpose, that of fixing part of what was formerly regarded as serum.

By homogenization the fat is brought together in large clusters and undoubtedly more or less serum is enclosed by the fat globules composing such clusters.

Fillers added to the ice cream mix are not used in large enough quantities to form a definite structure which would act as a steel frame of a building in supporting the whole structure. However, the beneficial results obtained from the fillers are as follows: first, increasing the viscosity of the mix, thus causing the incorporation of smaller air cells; second, increasing the strength of the air cell wall due to the increased viscosity of the cell wall. It is also quite probable that the cell wall increases in thickness as the viscosity increases and thus more of the liquid becomes fixed. Third, the filler increases the viscosity of the free liquid thus making it less fluid.

Any agent such as casein, filler or fat, which has the power to increase the viscosity of the mix or to take up and fix part of the liquid, becomes an important agent in the production of a desirable body. The main object is to bring the division of the mix to the finest possible point.

SHALL THE OVERRUN OF ICE CREAM OBTAINED BE FIGURED BY WEIGHT OR VOLUME?

The question has been asked at various times whether the overrun should be figured by weight or by volume of ice cream. In order to obtain definite information on that point, experiments were conducted and the results recorded in table XV. The same mix, made up from homogenized cream weighing, 8.856 lbs. per

TABLE XV—INFLUENCE OF TEMPERATURE OF DRAWING ON YIELD OF ICE CREAM. WEIGHT IN POUNDS OF 2 GALLONS WHEN DRAWN AT

No. of Expmt.	26 Deg. F.		26½ Deg. F.		27 Deg. F.	
	1st	2nd	1st	2nd	1st	2nd
1	10.91	10.92	10.76	10.78	10.70	10.70
2	10.51	10.59	10.41	10.85	10.28	10.28
3	9.85	10.17	10.35	10.29	9.60	9.60
4	10.81	11.62	10.59	10.72	10.34	10.94
5	11.19	11.44	10.28	10.28	9.75	9.75
6	10.37	10.69	10.34	10.37	9.62	9.62
7	13.03	13.19	12.94	13.16	12.81	12.81
8	13.09	13.31	13.06	13.19	11.22	11.50
9	12.75	12.78	12.25	12.59	11.78	11.78
10	13.00	13.31	12.53	12.81	11.00	11.59
11	11.16	11.66	10.56	10.87	11.19	11.66
12	11.19	11.47	10.25	10.47	10.59	10.50
13	10.59	10.66	10.22	10.47	10.34	10.37
Ave.	11.42	11.68	11.12	11.30	10.71	10.85
Per cent over-run	55.10	51.64	59.28	56.74	65.38	63.24

gallon, was used for each experiment. It was frozen in the disc continuous freezer, Size A. The circulating brine was kept at 10° F. The age of the cream and the temperature of the mixes differed for the various experiments. The ice cream was drawn at temperatures of 26° F., 26½° F. and 27° F. Two two-gallon containers of ice cream were weighed from each batch. The first container was filled with the ice cream first drawn from the freezer, immediately after it had reached the desired temperature. The second container was taken immediately after the first. If the overrun was figured on the first two gallons taken, then it would, for the ice cream frozen to 26° F., be

$$\frac{(8.856 \times 2) - 11.42 \times 100}{11.42}$$

or 55.10 per cent, while if it were figured on the second two gallons of the same batch the overrun would be only 51.64 per cent, or a difference of 3.46 per cent. For ice cream drawn at 26½° F., the difference in overrun was 2.54 per cent and for the 27° F. ice cream it was 2.14 per cent. The additional length of time at which the last part of the ice cream remains in the freezer will, as here shown, materially decrease the overrun; this decrease was greater for ice cream frozen to a lower than to a higher temperature.

The only reliable method to use in figuring the overrun for the day's freezing is to know how many gallons of ice cream have been made during the day and how much cream or mix has been used for the manufacture thereof. The mix may be measured or the volume of mix may be calculated when the weight and specific gravity thereof are known. The specific gravity of the mix used in these experiments was 1.0618. One hundred pounds of this mix will therefore be equal to

$$\frac{100}{8.34 \times 1.0618} = 11.29 \text{ gallons mix}$$

From this amount of mix 20 gallons of ice cream should be obtained and the overrun will then be equal to

$$\frac{20 - 11.29 \times 100}{11.29} = 77.15 \text{ percent}$$

This overrun figured from the mix is about equal to 100 per cent overrun when the overrun is figured from cream alone, provided the mix is made up from straight cream and flavoring material.

The value of knowing the desired weight of ice cream and its relation to the overrun should not, however, be disregarded, as it is very convenient to weigh a container of cream from time to time during a day's run. The work can thereby be checked up at any time and unnecessary losses avoided.

INFLUENCE OF HOLDING OF ICE CREAM ON UNIFORMITY IN FAT CONTENT

If ice cream is properly made, the fat will be uniformly distributed thruout because of the thoro agitation to which the mix is subjected in the ice cream freezer. If the original cream used is of a poor body, then the cream may churn more or less during the freezing, resulting in the presence of small butter particles. Such butter particles make an ice cream less desirable and practically unmarketable and such ice cream has therefore not been considered in the following experiment.

Manufacturers and dealers have believed that ice cream, if kept for several days, may become somewhat irregular in its fat content and it has been with some degree of fear that they have watched the inspector step into their stores to take a sample from a container in which only a small portion remains.

In order to determine the effect of holding ice cream on the uniformity of fat distribution, 32 five gallon samples of ice cream were kept packed in ice and salt for from 4 to 12 days. The ice cream was made from pasteurized cream with or without fillers and was usually held at temperatures ranging from 8 to 15° F., altho a few samples were held at a higher temperature, the ice cream being so soft in some instances that it did not stand up firmly after it was removed from the container.

When the ice cream was sampled, the container was taken from the tub and cold water poured over it until the ice cream slipped from the container onto a table, where the cylinder of ice cream was cut into four equal parts. Two samples were taken from each quarter and the fat content of each determined by the following method devised by Coover and Rudnick of this station.

With a wide mouthed, free flowing pipette weigh out 9 gr. of the melted and mixed sample into a 9 gr. 50% cream bottle. Add 1 c.c. of hot 10% gelatine solution, or 1.5 c.c. when much egg yolk has been added, shake vigorously and allow the mixture to stand for a few minutes, add 1-4H_2SO_4 saturated with $(NH_4)_2SO_4$ to fill the bottle to near the shoulder, centrifuge for five minutes at one-half greater speed than for the ordinary Babcock test. Incline the bottle, loosen the cake and remove the liquid by means o fa capillary tube. Add from 8-11 c.c. of water, shake to break up the cake and add H_2SO_4 as in testing cream. The amount of H_2SO_4 required usually falls within the limits of 7 and 11 c.c. The material must be thoroly charred in order to release all of the fat. Centrifuge for 5 minutes, add enough hot water to bring the fat to the neck of the bottle and centrifuge for two minutes more; now bring the fat into the neck of the bottle by carefully adding a mixture of denatured alcohol and

water having an approximate specific gravity of .93 and centrifuge for one minute.

The fat content of the various samples is shown in table XVI. In eleven experiments there was no difference in the fat content of ice cream taken from different places in the container. In 20 samples there was a slight difference ranging from 0.1% to 0.5% and in one sample there was a difference of 0.7%. These variations are so small that they may be considered due to experimental error.

Some of the samples were melted and held at a temperature above freezing for some time. In such cases a separation soon took place in melted ice cream made without filler, whereas ice cram to which 4 ounces of gelatin or the equivalent of other fillers had been added could be left in a melted condition for some time before a separation of fat from the serum was noticeable.

These experiments indicate that ice cream which is in a mar-

TABLE XVI—INFLUENCE OF HOLDING ICE CREAM ON UNIFORMITY IN FAT CONTENT.

No. of sample	Date Ice Cream was made	Date Analyzed	Pct. fat in top layer		Pct. fat in 2nd layer		Pct. fta in 3rd layer		Pct. fat in bottom layer		Average Per Cent Fat	Greatest Difference between any 2 samples
			1st Sample	2nd Sample	1st Sample	2nd Sample	1st Sample	2nd Sample	1st Sample	2nd Sample		
1	7-5	7-10	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.00	0.0
2	6	10	16.4	16.5	16.5	16.4	16.2	16.3	15.5	15.5	16.16	0.3
3	6	10	15.9	16.0	16.5	16.6	16.5	16.3	16.1	16.0	16.24	0.7
4	6	10	16.6	16.5	17.0	17.0	17.0	17.0	16.9	17.0	16.88	0.4
5	7	12	17.0	16.8	17.0	16.9	17.0	17.0	16.8	16.6	16.89	0.4
6	8	12	16.3	16.5	16.6	16.5	16.5	16.6	16.3	16.5	16.48	0.3
7	8	12	16.8	16.9	17.0	16.8	16.9	17.0	16.8	16.8	16.88	0.2
8	12	16	16.2	16.3	16.0	16.2	16.3	16.3	16.2	16.0	16.19	0.3
9	12	16	16.1	16.0	16.0	16.1	16.3	16.1	16.0	16.0	16.08	0.3
10	12	16	16.0	16.0	16.0	16.0	16.0	16.0	16.2	16.1	16.04	0.2
11	13	18	16.5	16.7	16.5	16.7	16.5	16.5	16.3	16.3	16.50	0.4
12	14	18	16.7	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.53	0.2
13	18	28	17.0	17.0	16.8	16.8	16.5	16.6	16.8	16.8	16.79	0.5
14	19	29	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.00	0.0
15	19	29	17.1	17.0	17.0	17.0	17.0	17.0	17.0	16.9	17.00	0.2
16	19	31	17.0	17.0	17.0	17.0	16.9	17.0	17.0	17.0	16.99	0.1
17	20	31	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.00	0.0
18	27	8-5	16.7	16.7	16.6	16.7	16.7	16.7	16.8	16.9	16.73	0.3
19	27	5	16.8	16.9	17.0	17.0	17.0	17.0	17.0	17.0	16.96	0.2
20	31	9	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.50	0.0
21	8-1	8	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.50	0.0
22	2	8	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.50	0.0
23	2	9	16.3	16.4	16.5	16.5	16.5	16.5	16.5	16.5	16.46	0.2
24	3	8	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.50	0.0
25	4	9	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.00	0.0
26	5	11	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.00	0.0
27	7	11	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.00	0.0
28	10	17	17.0	17.0	16.8	16.9	16.8	16.8	16.6	16.5	16.80	0.5
29	11	17	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.50	0.0
30	12	17	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.50	0.0
31	14	21	17.0	16.9	17.0	16.9	16.9	17.0	16.8	16.8	16.91	0.2
32	15	21	16.5	16.5	16.5	16.6	16.5	16.5	16.5	16.5	16.50	0.1

ketable condition may be fairly sampled from any part remaining in the container. If the fat separates from the serum, it is an indication that such ice cream has been completely melted. If melted ice cream is again frozen by merely packing the container in ice and salt, the resulting product is extremely icy and not marketable.

AMOUNT OF ICE AND SALT REQUIRED FOR FREEZING

In connection with the work reported on the previous pages a record was kept of the amount of ice and salt used for freezing the ice cream. This record was obtained by weighing the brine which was discharged from the freezer at each freezing. A disc freezer, size A, was used as a batch machine. The salt in the brine was determined by testing the brine with a standard silver nitrate solution, using potassium chromate as an indicator. As the salt used contained 3.2 per cent impurities, the amount of NaCl obtained in accordance with our determinations was multiplied by the factor $\frac{100}{96.8}$ to give the wight of salt.

Table XVII shows the relative proportion of ice and salt required for freezing ice cream to 27 to 26° F. It furthermore indicates a saving in freezing batches of normal size. A 25 pound mix was the normal batch for the freezer used and the amount of brine produced during freezing increased per ten gallons of ice cream frozen as the batches decreased or increased from normal.

In determining the cost of freezing 10 gallons of ice cream to 27 and 26° F., the cost of freezing a normal, or, as in these experiments, a 25 pound batch, should be taken as a basis. If ice costs $3.00 and salt $7.00 per ton, then the cost of ice and salt for freezing 10 gallons of ice cream to 27° F. is as follows:

$$\text{Cost of Ice} = \frac{(31 - 5.86) \times 300}{2000} = \$\ .0377$$

$$\text{Cost of Salt} = \frac{5.86 \times 700}{2000} = .0205$$

Total ..... $ .0582

If the ice cream is frozen to 26° F., then the cost of ice and salt for freezing 10 gallons of ice cream is as follows:

TABLE XVII—AMOUNT OF ICE AND SALT USED FOR FREEZING ICE CREAM.

Ice cream drawn from freezer at 27° F.

	15 lbs. mix			20 lbs. mix			25 lbs. mix			30 lbs. mix		
	Lbs. of brine used for freezing	Lbs. of salt in brine	% Salt in brine	Lbs. of brine used for freezing	Lbs of Salt in brine	% Salt in brine	Lbs. of brine used for freezing	Lbs. of salt in brine	% salt in brine	Lbs. of brine used for freezing	Lbs. of salt in brine	% salt in brine
Total am't used for 13 batches	153.75	29.50		175.50	33.61		201.50	38.04		245.25	45.96	
Average for each batch	11.83	2.27		13.50	2.59		15.50	2.93		18.87	3.54	
Ave. for freezing 10 gal. Ice Cream	39.43	7.57	19.20	33.75	6.47	19.17	31.00	5.86	18.90	31.45	5.57	17.71

Ice cream drawn from freezer at 26° F.

	15 lbs. mix			20 lbs. mix			25 lbs. mix			30 lbs. mix		
	Lbs. of brine used for freezing	Lbs of salt in brine	% salt in brine	Lbs. of brine used for freezing	Lbs of salt in brine	% salt in brine	Lbs. of brine used for freezing	Lbs of salt in brine	% salt in brine	Lbs. of brine used for freezing	Lbs of salt in brine	% salt in brine
Total am't used for 13 batches	170.50	32.60		230.75	42.84		259.25	49.14		332.75	63.51	
Ave. for each batch	13.12	2.51		17.75	3.30		19.94	3.78		25.60	4.89	
Ave. for freezing 10 gal. ice cream	43.73	8.37	19.14	44.37	8.25	18.59	39.88	7.56	18.96	42.67	8.15	19.10

$$\text{Cost of Ice} = \frac{(39.88 - 7.56) \times 300}{2000} = \$\ .0485$$

$$\text{Cost of Salt} \quad \frac{7.56 \times 700}{2000} = \quad .0265$$

Total ..... $ .0750

To this cost should be added the cost of reducing the brine to the temperature required for freezing the ice cream. This is an important item in a small factory, but quite insignificant in a large plant, where the freezers are operated for several hours in succession.

The cost of hardening and storing of ice cream after freezing is an important factor. We were not at this time in a position to furnish reliable data on such costs as they will vary greatly with the system employed, length of time for storing and insulation of storage room or tank.

A factor which may be considered as constant is the cost of packing ice cream for delivery. For packing a 5 gallon container of ice cream, 80 pounds of ice and 7 pounds of salt, or a cost of $.01445 per gallon will be required. This cost is naturally increased if the ice cream is packed in smaller containers.

The brine which is used for freezing the ice cream leaves the freezer at a temperature of from 12 to 14° F., while it enters the freeze rat 10° F. The brine, when salt and ice are used, is leaving the brine tank in a constant stream, corresponding to the amount of ice melted. A brine containing 19% salt has a specific heat of about .83, or a pound of such brine when heated from 14 to 32° F. will take up $(32—14) \times .83 = 14.94$ B. T. U. of heat. As refrigeration is expensive to produce, it would seem to be economy to collect the waste brine in a cooling tank and use it for cooling cream and milk. In many factories where ice and salt are used for freezing purposes, the waste brine from the freezers would be more than sufficient to cool the milk and cream handled.

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